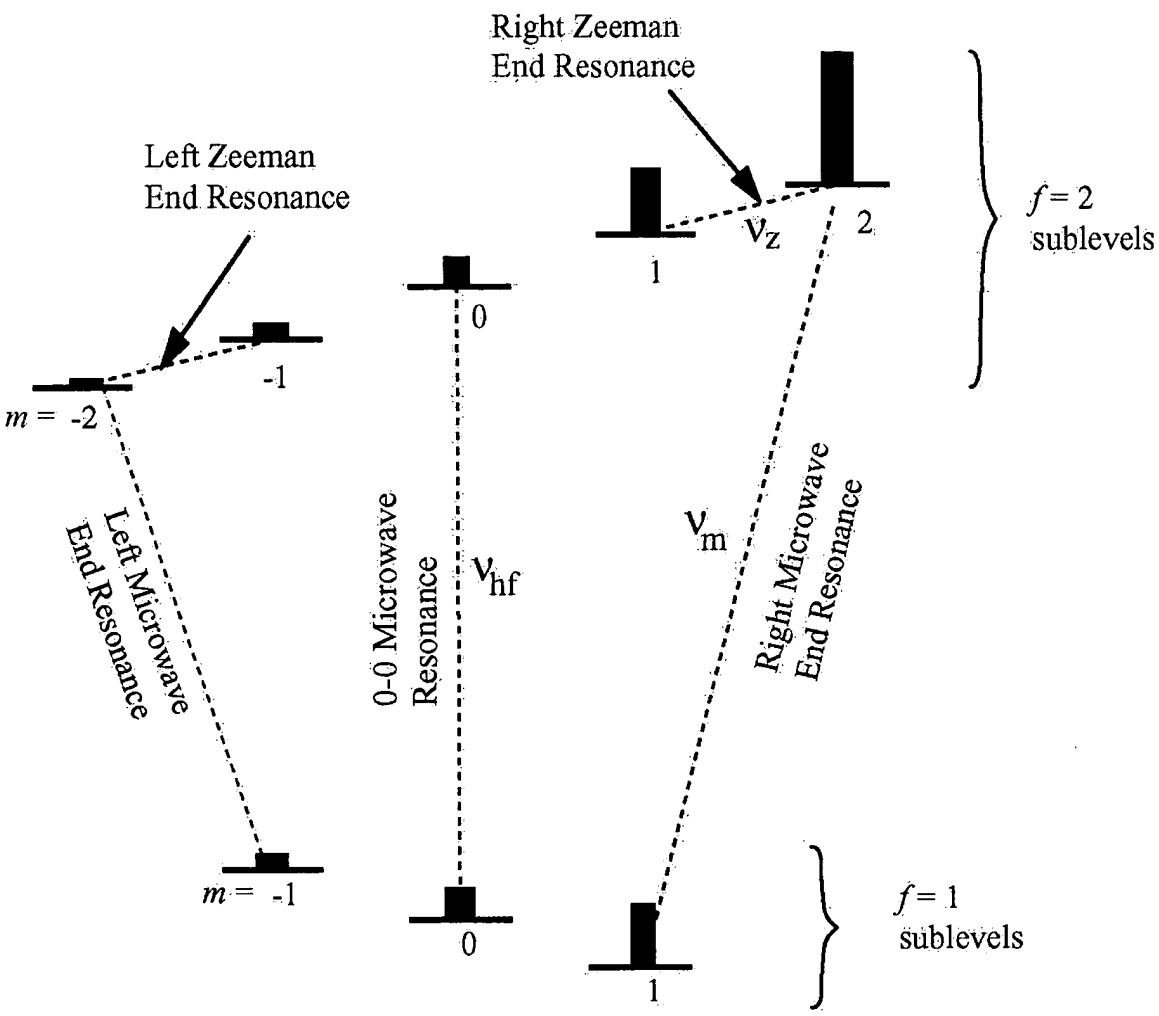

87 Rb Ground-State Energy Levels and Resonances
(not to scale)
Right Zeeman
End Resonance
Left Zeeman
End Resonance
ν_z
2
1
0
-1
m = -2
f = 2
sublevels
Left Microwave
End Resonance
0-0 Microwave
Resonance
ν_{hf}
ν_m
Right Microwave
End Resonance
m = -1
0
1
f = 1
sublevels

FIG. 1

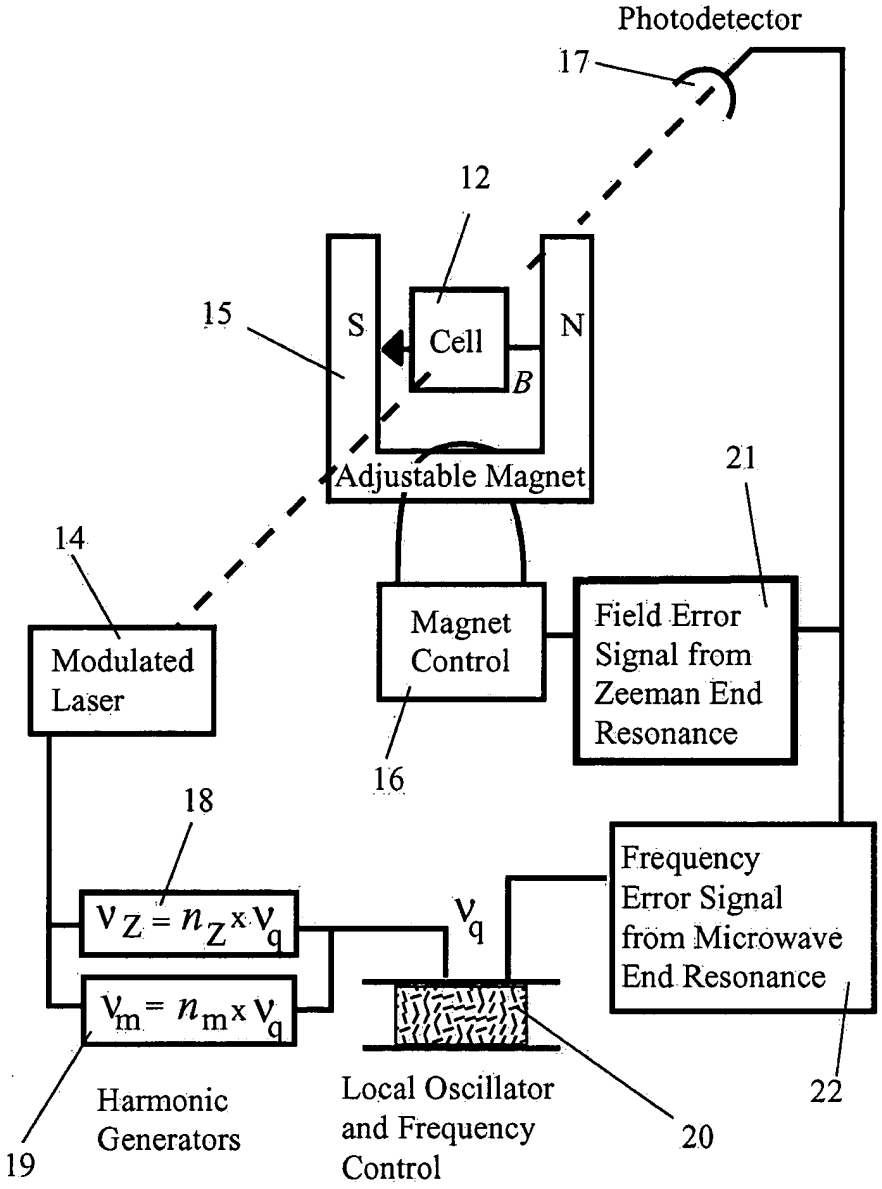
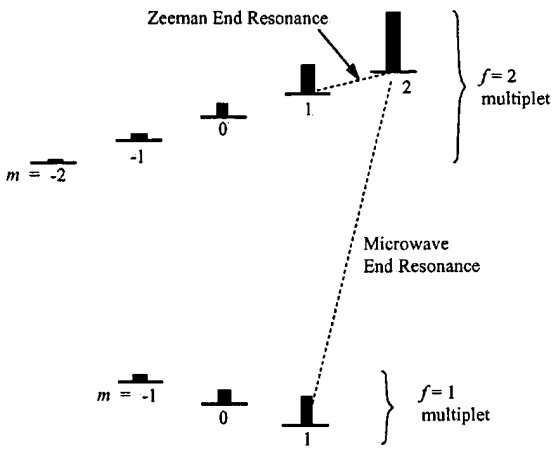

10
Photodetector
17
12
15
S
Cell
N
B
Adjustable Magnet
21
14
Modulated Laser
Magnet Control
Field Error Signal from Zeeman End Resonance
16
18
$\nu_Z = n_Z \times \nu_q$
$\nu_m = n_m \times \nu_q$
ν_q
Frequency Error Signal from Microwave End Resonance
19
Harmonic Generators
Local Oscillator and Frequency Control
20
22

FIG. 2

30

Optically pumping atoms into a ground-state sublevel of maximum (or minimum) spin m from which end resonances can be excited

32



Simultaneously exciting a microwave end transition and a Zeeman end transition in the atoms with laser light doubly modulated at, or magnetic fields simultaneously oscillating at a microwave frequency of the end resonance and a Zeeman frequency of the end resonance

34

Adjusting the applied magnetic field and the oscillator frequency used for generating the microwave frequency and Zeeman frequency in such a way as to maximize the photo detector signal

36

FIG. 3

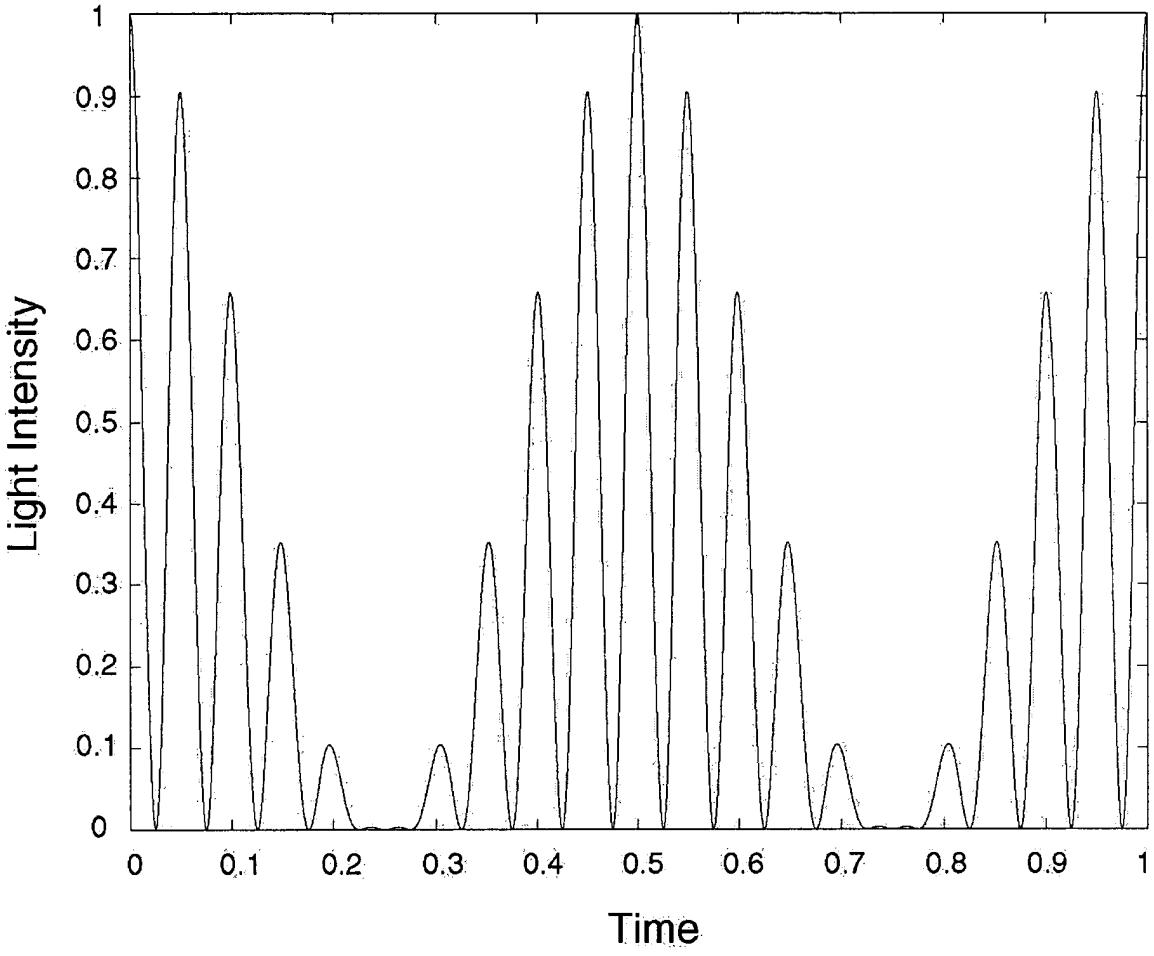


FIG. 4

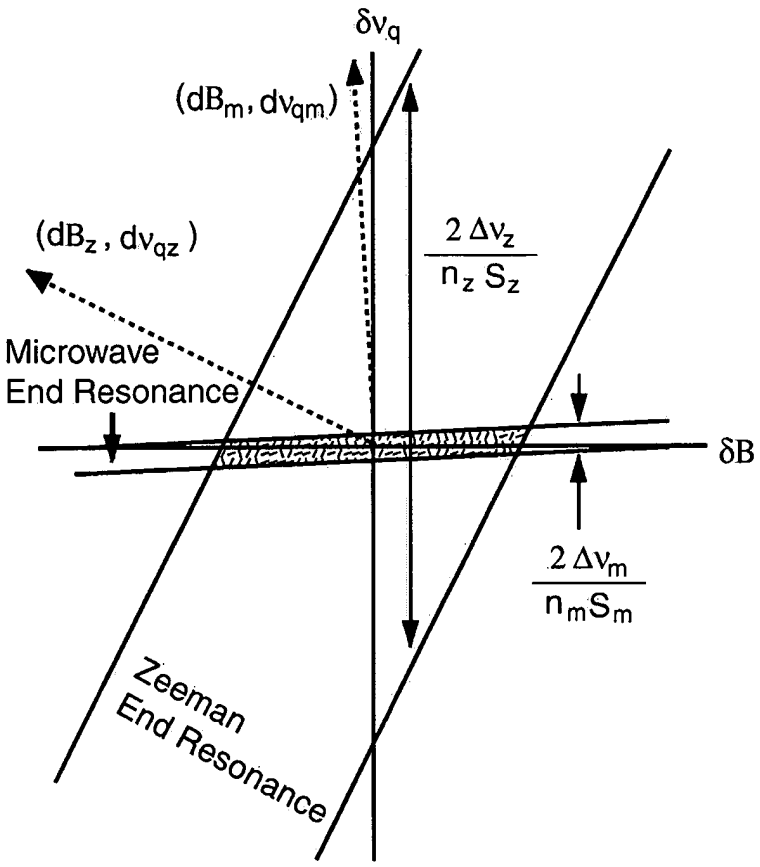

δν_q
(dB_m, dν_qm)
(dB_z , dν_qz)
Microwave
End Resonance
2 Δν_z
n_z S_z
δB
2 Δν_m
n_m S_m
Zeeman
End Resonance

FIG. 5

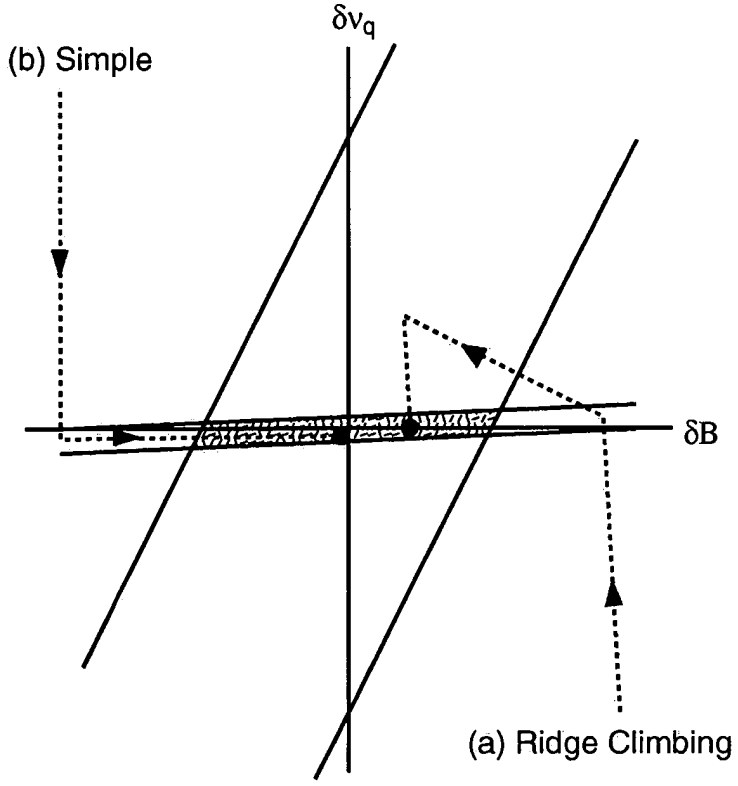


FIG. 6

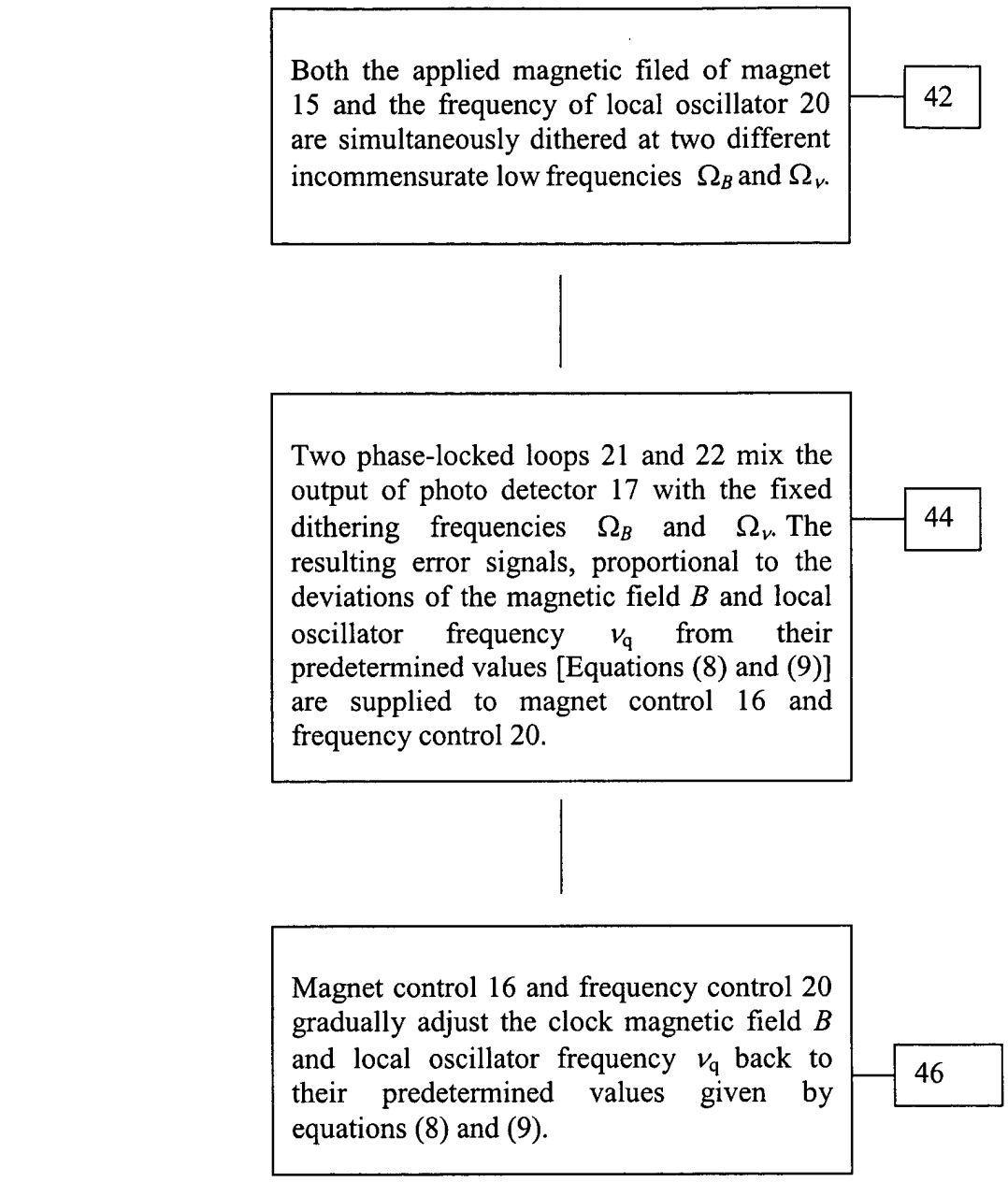

40
Both the applied magnetic filed of magnet 15 and the frequency of local oscillator 20 are simultaneously dithered at two different incommensurate low frequencies Ω_B and Ω_ν.
42
Two phase-locked loops 21 and 22 mix the output of photo detector 17 with the fixed dithering frequencies Ω_B and Ω_ν. The resulting error signals, proportional to the deviations of the magnetic field B and local oscillator frequency ν_q from their predetermined values [Equations (8) and (9)] are supplied to magnet control 16 and frequency control 20.
44
Magnet control 16 and frequency control 20 gradually adjust the clock magnetic field B and local oscillator frequency ν_q back to their predetermined values given by equations (8) and (9).
46

FIG. 7